Tecnews

A publication for the presentation of new ideas . . . new methods . . . new products . . . in the associated fields of radio and electronics.

PUBLISHED MONTHLY BY THE

ELVIN W6TT **ELECTRIC SUPPLY CO.** MARIO W6DUB

149 12th STREET, OAKLAND 7, CALIFORNIA

JANUARY 1951

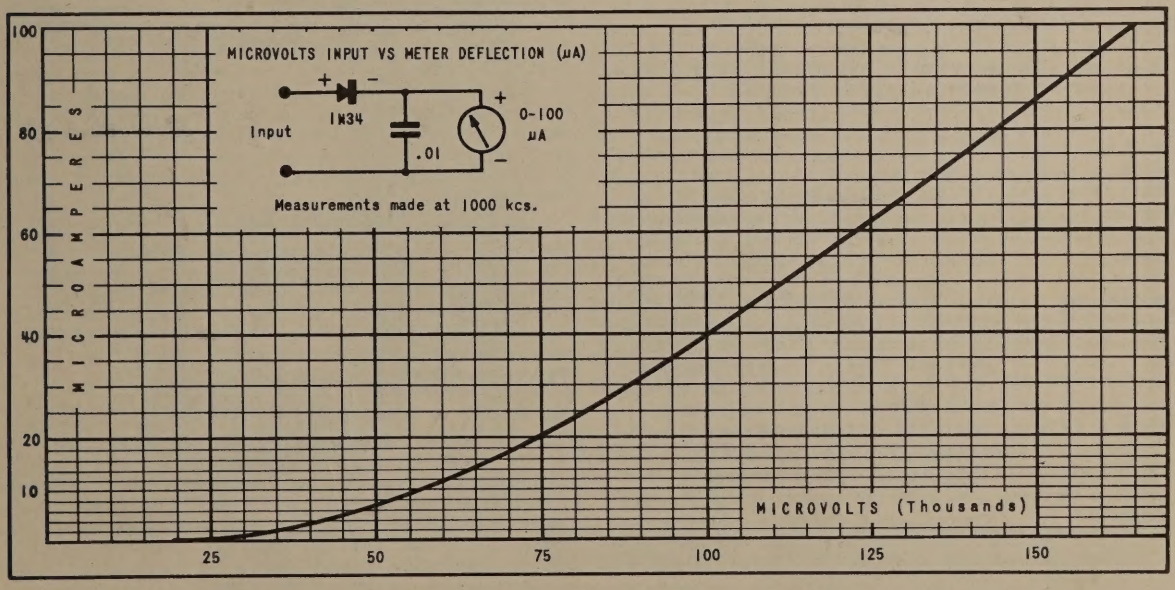
HOW WEAK ARE YOUR HARMONICS?

By Clayton F.Bane, W6WB

When the amplitude of harmonics from an amateur transmitter are reduced by application of various corrective measures, it is assumed that a point will ultimately be reached where the sensitivity of the measuring device will become inadequate. This is to say that, even though the harmonic may ultimately be reduced to the point where the indicating instrument will no longer produce deflection, harmonic interference to the TV picture may still be very much in evidence. This brings up two factors for consideration: First, a more sensitive harmonic measuring device. Second, the amount by which the harmonic must be reduced in order to be negligible in comparison with the TV picture. Both factors are important and will bear some further discussion.

It will be apparent that the degree of harmonic attenuation necessary to insure freedom from interference is very definitely tied in with the field strength of the TV station, (operating on the harmonically related channel) in a particular locality. Since TV station field strength may vary widely in many locations, it is not at all safe to generalize. Thus, harmonic reduction techniques applied to a transmitter in an area where the TV field strength happens to be high, may prove to be totally inadequate when applied to a transmitter located in a region where the field strength is low. Actual distance from the TV station is not necessarily a criterion of the field strength to be expected. For example, within the City of San Francisco there are areas where KRON, (Channel 4) will vary between a high of over 20,000 and a low of 500 microvolts! (Small doubt but that other stations in this area vary by a like amount). It is only reasonable to expect that the amateur situated in the 20,000 microvolt area is going to have less difficulty in reducing his fifth harmonic, (from 14 mc) to a value below the point of interference than will an unfortunate amateur who is located in the 500 microvolt area. These two extremes of TV signal levels represent a voltage ratio of 40:1 or 32 decibels.

We have heard many amateurs proudly state that particular harmonics from their transmitters were so weak that just the slightest of indications could be observed on their indicating instruments. The question naturally arises as to whether the harmonics were actually very weak or, much more probably, the pick-up device very insensitive.



Most of the more simple pick-up devices use a crystal rectifier,(1N34) in conjunction with a microammeter and operate as an RF voltmeter. This rectifier-meter combination is of course connected across an L/C circuit tuned to the desired harmonic frequency. Most use a 0-100 microammeter...a few 0-50...a very few 0-25 microammeters. The very lamentable fact about even the most sensitive of these combinations is that they are completely inadequate for anything but rough preliminary measurement. In other words, if one can just barely see the pointer move up from zero, the amplitude of the harmonic is generally greater than the strongest TV signal! This can be readily verified by referring to the curves in Fig.1,... these represent actual plots of microammeter readings for a given microvolt signal input. Since individual crystals may vary somewhat in their sensitivity, measurements were made using three different crystals to arrive at a typical average value. It will be painfully evident that the first visable movement of the instrument pointer will correspond to about 20,000 microvolts...a really terrific signal in terms of TV station field strength. Further observation of the curve will show that the reading of the microammeter is not linear,... that the scale tends to "bunch" at the bottom. This in itself makes it very difficult to try to evaluate the effectiveness of traps,filters or other devices that might be installed in an effort to reduce the harmonic. Lest we havn't yet put over the point that this type of harmonic measuring device is hardly worthwhile, let us once again review the problem in terms of TV station field strength.

Let us assume that the particular TV receiver is in a strong signal area where the field strength is the equivalent of 5000 micro volts at the input terminals of the receiver. Remember, this is strong and receivers in this area will be receiving excellent pics. 5000 microvolts across an input impedance of 300 ohms, (average TV receiver input impedance) represents a power of only .000000083 watts! Assume further that an amateur transmitter with a carrier power of 500 watts might produce a signal at the terminals of the TV receiver amounting to .01 of 1% of the 500 watt carrier or .05 watts. This estimate is reasonable for a transmitter without harmonic reduction treatment. The ratio of the two powers works out to be 510,240:1 or 57.7 db. In this instance one starts off with an interfering harmonic some 57 db stronger than the TV signal. Since a low-pass filter offers the best means of achieving a large attenuation of the harmonic, let's consider the effectiveness of such a filter under the stipulated conditions.

The attenuation of a low-pass filter of the Constant K type at any given harmonic frequency beyond its cut-off point will depend upon how far removed this harmonic frequency is from the cut-off frequency. Typical filters for amateur application have a cut-off frequency at 44 mcs. Thus a fifth harmonic from 14 mc would fall at 70 mcs which is less than one full octave removed from the 44 mc cut-off point. Bearing in mind that the filter will have an attenuation of some 16 db/octave and that this figure will be multiplied by the number of filter sections used, (usually 4) this typical filter will have an attenuation of approximately 60 db at 70 mcs. Note that the filter may likewise employ terminating "M" sections. With 44 mc cut-off, an "M" of .6 would bring a notch of very high attenuation at 55 mcs thus affording substantial reduction to harmonics falling in or near Channel 2. Consider once again the typical case where the fifth harmonic from 14 mcs showed a differential of 57 db over the TV signal on Channel 4. Everything else being equal, the typical filter with a total attenuation of 60 db would merely reduce the strength of the harmonic to a value approximately equal to the television signal!

Here is a case where a perfectly good filter was used...the filter provided the maximum possible attenuation of which it was capable, yet the harmonic interference was not eliminated. It can be seen that the problem requires the answer to an important question,how strong is the harmonic in relation to the TV signal? We cannot state with exactness just what the interference-free ratio between the two signals should be but we can fall back upon some actual examples. In one particular case, the TV signal was about 500 microvolts/meter and that from the amateur station approximately 100 microvolts/meter yet interference was observable on the TV picture.

It is definitely not the intent of this brief paper to regard harmonic elimination in a pessimistic light. In the examples given it would have simply been necessary to reduce the harmonics from the output of the transmitter before the filter was added. This might have been readily accomplished by traps, increasing the L/C ratio, elimination of harmonic resonant circuits within the final amplifier or an additional low-pass filter between driver and final amplifier. In any case, it can be done.

We cannot emphasize too strongly the necessity for harmonic measuring equipment having greater sensitivity than can be obtained with the conventional crystal rectifier/microammeter combination. When the harmonic has been reduced until the microammeter approaches zero the job is not finished....it's merely beginning! However, one thing is certain...if it is necessary to reduce harmonics to a very low value it will be equally necessary to be able to quantitatively observe and evaluate the various corrective measures as they are applied. This points up the need for a measuring instrument that will provide readable indication down to about 100 microvolts. An inexpensive and readily constructed device to accomplish this result will be described in a subsequent issue of TECNEWS.

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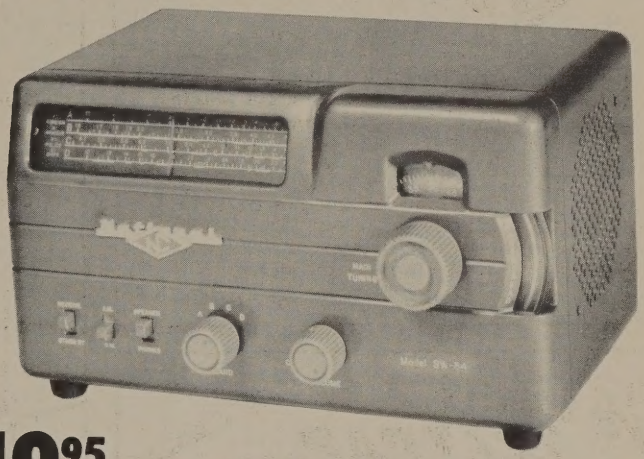

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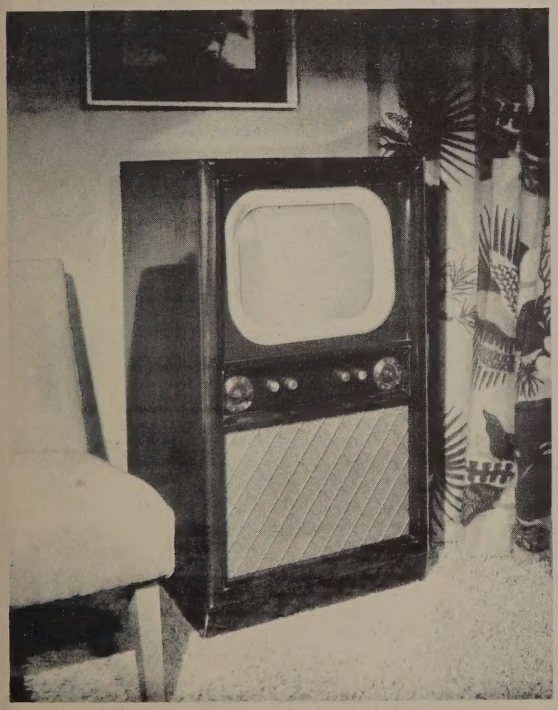

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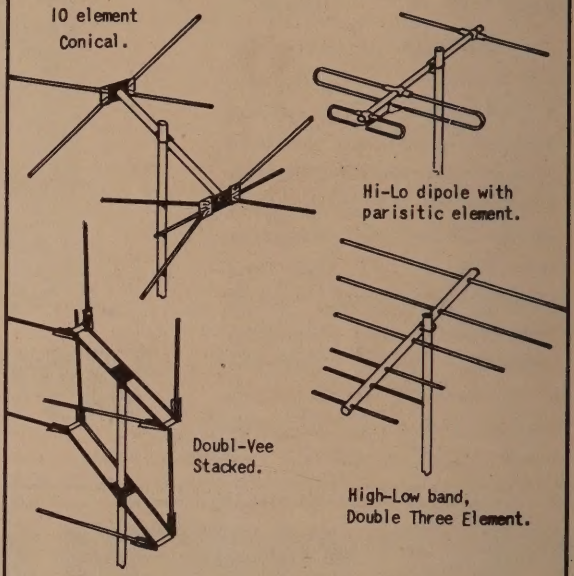

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